Original Articles

Appraisal of pediatric cardiopulmonary resuscitation

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Sixty-six patients more than 30 days and less than 16 years of age suffering an unexpected cardiac arrest in an 18-month period were included in a study of resuscitative measures in children. Six children survived to be discharged from hospital. Respiratory disease accounted for most (29%) of the cardiac arrests, but it also had the most favourable prognosis, 21% of the 19 patients surviving. None of the patients survived whose cardiac arrest was secondary to sepsis or trauma, even when the resuscitative efforts were initially successful. Only 1 of the 41 patients who had a cardiac arrest outside of hospital survived, and only 1 of the 34 patients who presented with asystole survived, and then with considerable damage to the central nervous system. The interval between cardiac arrest and application of basic life support was substantially shorter among the survivors. Also, most of the survivors did not present with asystole. The results of this study suggest that survival among resuscitated children is no better than that among adults but can be improved with early recognition and monitoring of children at risk, earlier application of basic and advanced life support, improved education of medical and lay personnel, and further research into pediatric resuscitative techniques.

Soixante-six patients âgés de plus de 30 jours et de moins de 16 ans, victimes, au cours d'une période de 18 mois, d'un arrêt cardiaque imprévu, ont été inclus dans une étude portant sur les mesures de réanimation chez l'enfant. Six enfants ont survécu et ont reçu leur congé de l'hôpital. Les maladies respiratoires étaient responsables de la plupart (29%) des arrêts cardiaques, mais elles avaient néanmoins le pronostic le plus favorable, alors que 21% des 19 patients ont survécu. Aucun des patients dont l'arrêt cardiaque était secondaire à une sepsie ou à un traumatisme n'a survécu, même lorsque les tentatives de réanimation étaient initialement couronnées de succès. Un seul des 41 patients qui ont subi un arrêt cardiaque hors de l'hôpital a survécu, ainsi qu'un seul des 34 patients qui sont arrivés en asystole, et alors avec des dommages cérébraux considérables. La période écoulée entre l'arrêt cardiaque et la mise en oeuvre d'un équipement de survie de base était considérablement plus courte chez les survivants. De plus, la plupart des survivants ne sont pas arrivés en asystole. Les resultats de cette étude indiquent que la survie chez les enfants réanimés n'est pas meilleure que celle chez les adultes mais qu'elle peut être améliorée par la reconnaissance précoce et la surveillance des enfants menacés, l'utilisation plus rapide d'équipements de survie de base ou perfectionnés, l'amélioration de la formation du personnel médical et auxiliaire, et l'avancement de la recherche dans le domaine des techniques de réanimation pédiatriques.

The efficacy of cardiopulmonary resuscitation (CPR) in the pediatric population remains unclear. Published reports of cardiac arrests and resuscitative efforts in children are often limited to in-hospital events, are often reports of single cases and are largely anecdotal.[1,2] However, excellent outcomes have been reported in special population groups: those who have nearly drowned and have associated hypothermia[3] and those who have taken an overdose of a hypnotic drug respond well to resuscitative efforts and subsequent life-support techniques. We examined the results of pediatric CPR applied to a larger community setting and a variety of disease states in order to determine prognostic indicators and whether CPR has a more favourable outcome in children than in adults.

Method

The study encompassed all detected cases of unexpected cardiopulmonary arrest (defined as lack of a central arterial pulse) occurring in patients between 30 days and 16 years of age between July 1977 and December 1978 in Manitoba (population approximately 1 million). Study sheets from the University of Manitoba's resuscitation research project[4] were distributed to all health care centres in advance. The staff of the admitting hospitals filled in the sheets for all patients at the time of their cardiac arrest. Both urban and rural hospitals were included, as were all patients having a cardiac arrest, whether in or out of hospital. Therefore,

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our study examined resuscitative efforts at all levels of health care delivery.

The study sheets and data were reviewed at the end of the study period, and patients were divided into three categories: (a) those who were discharged from hospital, (b) those who survived 24 hours or more but died before discharge from hospital and (c) those for whom resuscitative efforts were unsuccessful.

All instances of resuscitation and most of those of unsuccessful resuscitative efforts were analysed for factors bearing on outcome. The time required to apply basic CPR was recorded from the time an emergency phone call was received or an in-hospital call was issued. In all cases CPR was instituted by trained personnel after apnea and a nonpalpable pulse were recognized.

Results

A total of 66 pediatric patients had an unexpected cardiopulmonary arrest in the study period. Six (9%) of the patients survived to be discharged from hospital: three were considered neurologically and physically normal, two were discharged with seizure disorders thought to be due to cerebral hypoxia that occurred at the time of cardiac arrest, and one, with severe neurologic deficits, was transferred to another institution for long-term care. Another six patients survived more than 24 hours (mean 4.4 days) but were subsequently pronounced "brain-dead"; therefore, cardiac support was withdrawn or further resuscitation discontinued.

More than half the patients (36) were less than 1 year of age, and generally their outcome was less favourable (Fig. 1). The success rate of CPR performed in hospital was significantly better than that performed outside hospital. Five of the six patients for whom CPR was successful were in hospital; the other patient had been given mouth-to-mouth resuscitation at home by his mother, who had had previous medical experience (Fig. 2).

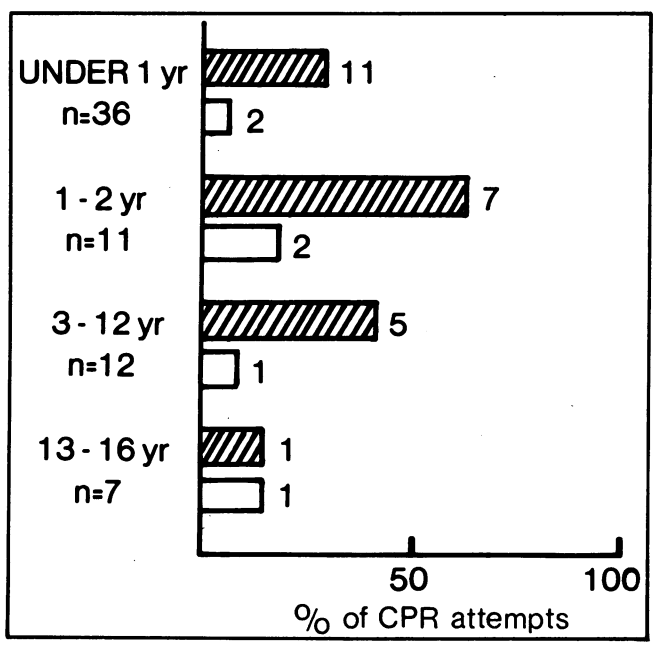

FIG. 1—Age distribution at time of cardiac arrest. In first four figures hatched bars represent initial success (resuscitation resulting in admission to hospital or to intensive care unit [ICU] from ward) and white bars represent hospital discharge (survival to time of discharge). CPR = cardiopulmonary resuscitation.

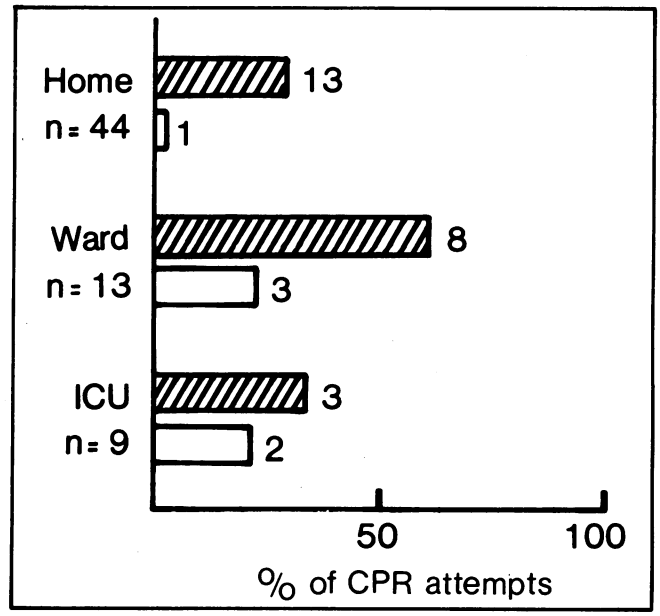

FIG. 2—Relation between site of arrest and outcome. Resuscitation in hospital significantly more successful (P = 0.0156 by Fisher's exact test) than that at home.

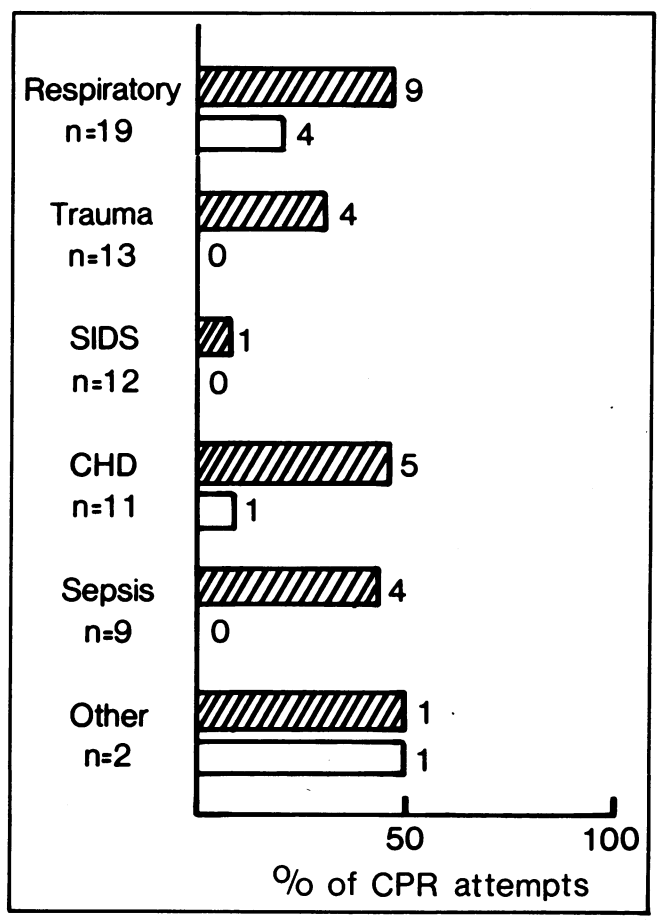

FIG. 3—Cause of arrest. SIDS = sudden infant death syndrome. CHD = congenital heart disease.

In 24 patients the results of CPR were initially promising, as indicated by the restoration of cardiac rhythm and function. However, only one quarter of these patients survived to be discharged from hospital. One patient, with congenital aortic valvular disease, had been resuscitated on two occasions more than a year apart.

The response to CPR efforts was related to the cause of the cardiac arrest (Fig. 3), a successful outcome occurring mainly in patients who had had a cardiopulmonary arrest secondary to respiratory disease. Only one patient, a 1-year-old boy, had had a cardiac arrest following ingestion of a drug (a tricyclic antidepressant), which resulted in recurrent ventricular tachycardia; he was successfully treated with physostigmine salicylate. There were no survivors among the patients who had had a cardiac arrest secondary to trauma or sepsis. Resuscitative efforts were unsuccessful in a patient who had drowned in fresh water, an adolescent with uncontrolled diabetes and 12 infants with sudden infant death syndrome.[5]

Of the 44 patients whose cardiac rhythm was recorded at the time of presentation to hospital 34 had asystole, and only 1 of the 34 survived (Fig. 4), and then with profound brain damage. In contrast, 4 of the 10 patients who presented with a cardiac rhythm (ventricular tachycardia or ventricular fibrillation) were resuscitated. Many of the patients who initially responded to therapy but ultimately died had suffered severe anoxic brain damage; therefore, life support had been stopped.

There was no relation between the duration of initial cardiopulmonary support and outcome. However, as has been demonstrated in adults,[6] an important prognostic feature for survival besides the precipitating event is the interval between probable cardiac arrest and institution of active CPR (Fig. 5). In our study the interval was 2.3 minutes in the survivors and 6.5 minutes in those who did not survive, a statistically significant difference ($P < 0.05$ by Wilcoxon rank sum analysis).

Discussion

It is not the purpose of this report to suggest that the management of these patients was ideal or even reflected pediatric care in general. Rather, this report was intended as a critical review of generally accepted methods of pediatric resuscitation as practised in the community. Because of the tremendous emotional and financial burden associated with the administration of acute or chronic care to children who have had a cardiac arrest, the efficiency of resuscitative efforts must constantly be evaluated.

Our study had obvious limitations. The data were entered at the time of cardiac arrest by various medical personnel, and, although the study was initiated prospectively and the data were correlated by a single individual, several factors required a retrospective review of the data. Because of the emotion of the situation the reported times of cardiorespiratory arrest, especially for patients outside hospital, may not be accurate. Our patients were from both urban and rural areas and included all those having a cardiac arrest, whether in or out of hospital. We would expect the level of care to vary with the location of the arrest. However, widespread instruction in CPR throughout Manitoba has generally standardized basic life-support techniques.

The application of CPR techniques can sustain life in children who have had a cardiac arrest. Some authors believe that children may be more resistant to hypoxia than adults.[7] However, our data do not support this impression. Our survival rate of 9% is no better than that reported in adults.[8,9] In one study, mostly of adults, the rate of success of resuscitative attempts was greater when the attempts were begun less than 10 minutes after the cardiac arrest.[8] Similarly, among the children in our study CPR was begun less than 10 minutes (mean 2.3 minutes) after the arrest in all the survivors; the interval in the patients who did not survive was 6.5 minutes.

Other variables in our study suggest a more favour-

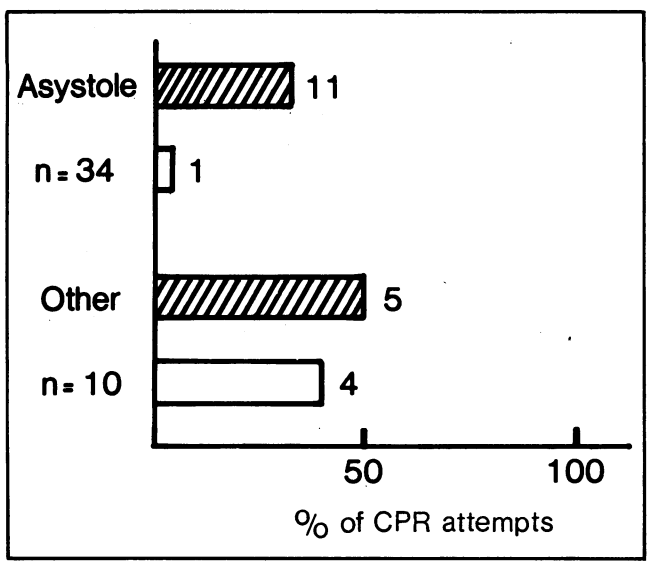

FIG. 4—Relation between cardiac rhythm, as determined from initial electrocardiogram, and outcome.

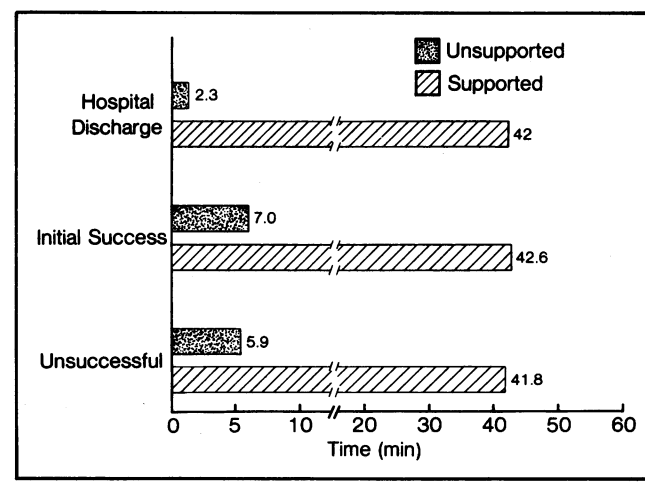

FIG. 5—Relation between CPR support and outcome. Unsuccessful denotes failure to restore cardiac rhythm and function. Unsupported denotes absolute mean time between cardiac arrest and institution of basic life support. Supported denotes absolute time during which CPR was employed.

able prognosis; for example, if the cause of the arrest is respiratory disease, if the arrest occurs in hospital and if a cardiac rhythm is detectable at the time of presentation. The clinical manifestations of the respiratory diseases may have alerted the attendants to pay closer attention to these patients than to some others. The site of the cardiac arrest had the strongest influence on outcome. The patients who had had an arrest outside hospital fared poorly for several reasons: the unexpected and sudden nature of the event, ineffective or improper application of CPR, a prolonged interval between the arrest and the institution of CPR, and, possibly, the cause of the arrest.

Our results imply that the presence of asystole in children carries the same grave prognosis as it does in adults. Only 1 of the 34 patients who initially had asystole survived, and this patient had severe cerebral damage, whereas 4 of the 10 patients who initially had a cardiac rhythm survived.

In another study we reviewed 14 neurologically dead children for whom respiratory support had been terminated in our intensive care unit. The mean interval between apnea and asystole was 16.7 minutes, which implies that a normothermic patient who presents with asystole as a secondary event has already had prolonged hypoxemia and suffered brain damage.

The earlier application of basic life support by trained medical and lay personnel would improve survival. In our study the interval between arrest and institution of CPR for the patients who survived was less than half that for those who did not.

In summary, CPR techniques can and should be used in children who have a cardiac arrest. The ultimate survival of these patients may be no better than that of adults with coronary artery disease. Prevention or at least early intervention in such patients requires identification and improved observation of children at risk. The pediatric intensive care unit, with its one-to-one nursing, may therefore provide a greater service in preventing cardiac arrest than in treating the consequences.

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Prognosis after cardiac arrest based on age and duration of coma

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In an attempt to determine the relation between duration of coma and neurologic recovery following cardiac resuscitation 163 survivors of cardiac arrest from Winnipeg, Manitoba and Aarhus, Denmark were studied. The age of the patients did not influence the outcome. Of the 153 patients who had wakened from the coma within 24 hours, only 11 suffered brain damage, compared with all of the 10 patients who wakened after 24 hours. The three who wakened after 72 hours had severe brain damage and required permanent care in an institution. It was concluded that recovery of communicative brain function is unlikely if coma persists longer than 72 hours after cardiac arrest and that full recovery cannot be expected after 24 hours of coma.

Dans l'espoir d'établir un rapport entre la durée du coma et le rétablissement neurologique consécutifs à une réanimation cardiaque 163 personnes de Winnipeg, Manitoba et de Aarhus, Danemark qui ont survécu à un arrêt cardiaque ont été étudiées. L'âge des patients n'a eu aucune influence sur les résultats. Des 153 patients qui on repris conscience en moins de 24 heures, seulement 11 ont souffert de dommages cérébraux, alors que les 10 patients qui on repris conscience après 24 heures souffraient tous de tels dommages. Les trois qui sont sortis du coma après 72 heures avaient des dommages cérébraux sévères et ont nécessité des soins permanents en établissement. On conclut que la récupération des fonctions cérébrales de communication est peu probable lorsque le coma persiste plus de 72 heures après un arrêt cardiaque et qu'un rétablissement complet ne peut être anticipé après 24 heures de coma.

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Survivors of cardiac arrest use a substantial amount of our intensive care resources. Patients who remain